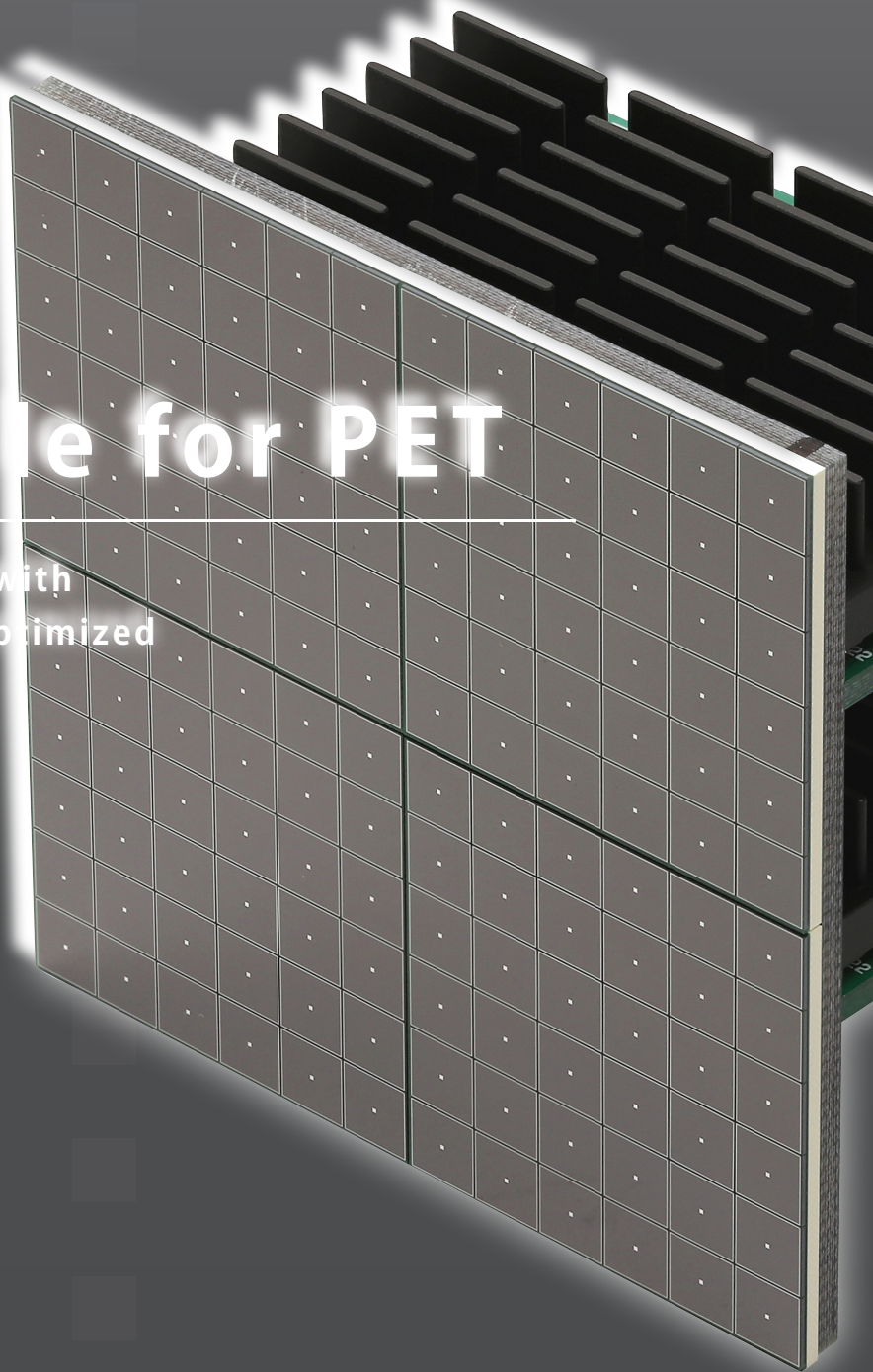
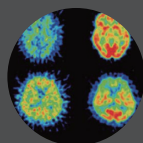
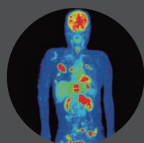


MPPC module for PET

By combining our MPPC device with circuit technologies, we offer optimized modules and circuits for PET.



HAMAMATSU
PHOTON IS OUR BUSINESS

DETECTOR

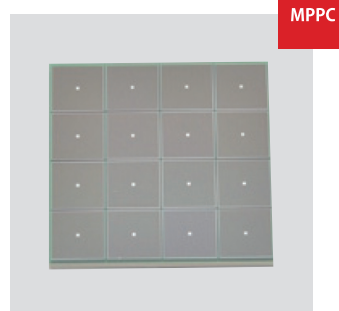
MPPC array



The MPPC is one of the devices called silicon photomultipliers (SiPM). The S13361 series is an MPPC (SiPM) array for precision measurement. It inherits the superb low afterpulse characteristics of its predecessor and further provides lower crosstalk and lower dark count. This MPPC array uses through-silicon via (TSV) to minimize non-sensitive portions around the photosensitive area.

Features

- Reduced crosstalk and dark count (compared to previous products)
- Low afterpulse
- Outstanding photon counting capability (outstanding photon detection efficiency against incident photons)
- Excellent uniformity
- Low voltage operation



ASIC

An ASIC optimized for precision measurement. This ASIC along with the MPPC array is mounted on a custom PCB.

Features

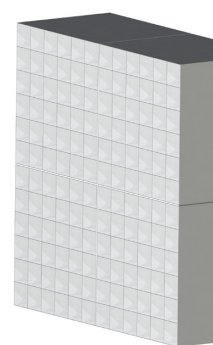
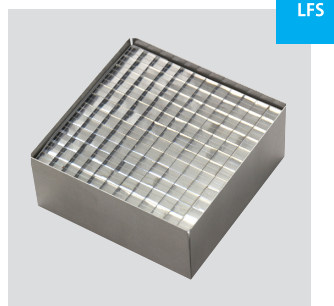
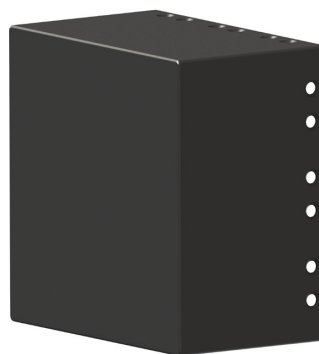
- Designed speed
- Signal processing in a single circuit
- Low power consumption
- 18 ch / chip

SCINTILLATOR

The LFS scintillator features high light emission yields and fast decay time. Combining this scintillator with the MPPC enables the construction of excellent PET imaging systems, such as TOF-PET.

Features

- High light output
- Superior time resolution
- No deliquescence unlike CsI

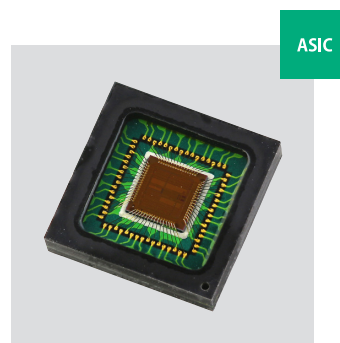
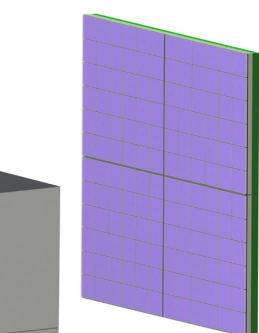


POWER

The power supply is designed to power the MPPC array. It has a temperature compensation function to keep the operation stable. A single power supply can power multiple MPPC arrays.

ed for the MPPC in the MPPC module and LFS scintillator was specifically designed.
with TDC, FPGA, and other signal processing circuits necessary for TOF-PET are
compact circuit board. This is incorporated in the PET module.

cifically for the PET module
sing circuits necessary for TOF-PET consolidated
cuit board (C14139-01)
nsumption

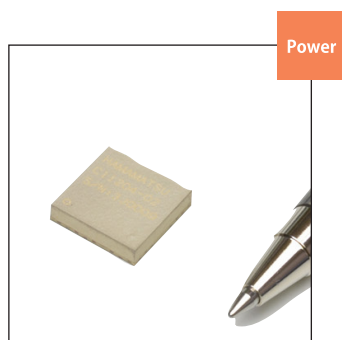


PET module

Hamamatsu PET modules consist of MPPC arrays, scintillators, and ASICs. Each part has optimum specifications for PET. Using these modules can make your PET device development more efficient. Further, Hamamatsu provides not only the light detection section but also latter-stage circuits and interface boards. Depending on your needs, you can also purchase these parts separately.

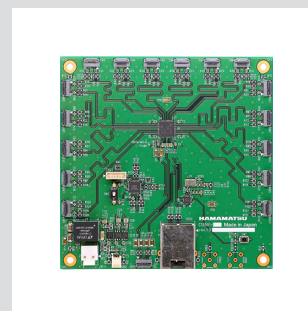
POWER SUPPLY

pply is for driv-
C. It contains a
compensation
keep the MPPC
le.
r supply can run
arrays.






PERIPHERAL CIRCUIT

The power supply unit and peripheral circuits (sold separately) are for running the PET module properly.



PET module

These modules are installed in a PET device. These integrate an MPPC, scintillator, and ASIC board.

Type no.	C13500-4075LC-12	C13500-3075LC-16	C13500-6075LC-16 (Light sharing type)*
Photo			
Scintillator size / ch	4 × 4 mm (12 × 12 ch)	3 × 3 mm (16 × 16 ch)	3 × 3 mm (16 × 16 ch)
MPPC size / ch	4 × 4 mm, 75 μm pitch	3 × 3 mm, 75 μm pitch	6 × 6 mm, 75 μm pitch
Count rate	< 500 kcps	1 Mcps	< 250 kcps
CRT (FWHM)	< 280 ps	< 280 ps	< 400 ps
Power consumption	2.6 W	5 W	1.3 W

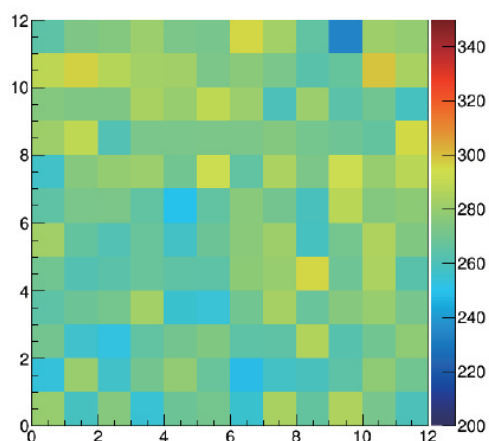
* A method in which light output from the scintillator is read out using an MPPC array with spacing greater than that of the scintillator.

Features 1

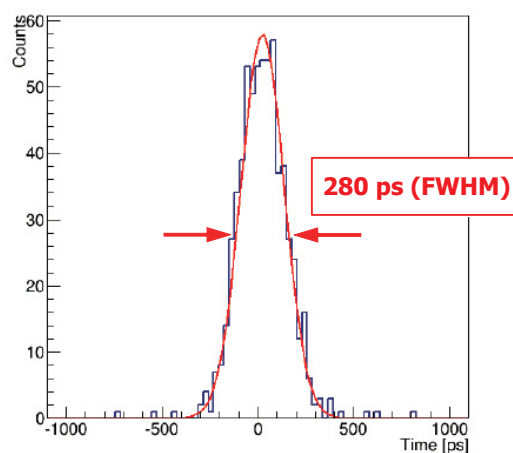
Excellent time resolution: 280 ps

- CRT (FWHM): 280 ps
- CRT variation (12 × 12 ch): ±15 ps max.

■ 2D-map of CRT (C13500-4075LC-12)



■ Histogram of CRT (C13500-4075LC-12)



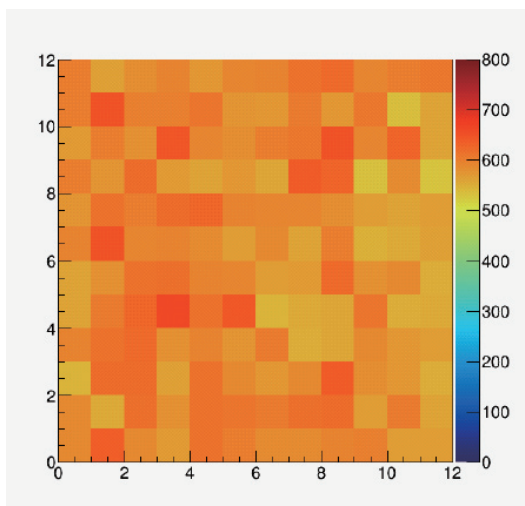


Features 2

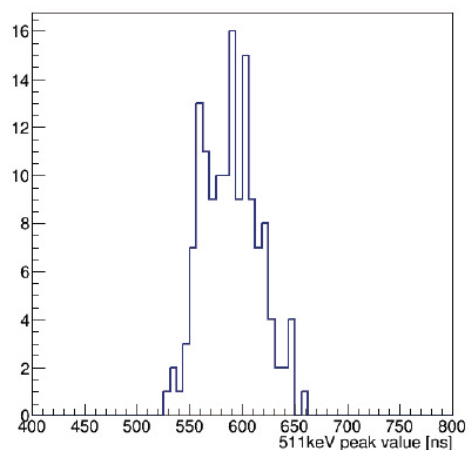
Outputs energy information of all channels

As the energy information of the PET module is processed using time over threshold, it is output as time information.

■ 2D map of energy peak
(C13500-4075LC-12, 511 keV)



■ Histogram of energy peak
(C13500-4075LC-12, 511 keV)



Features 3

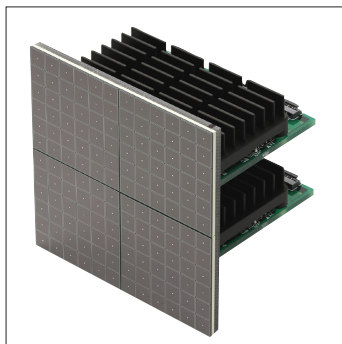
Customizable for OEM

Customization is possible according to your needs.

Consult with your nearest Hamamatsu sales office.

Examples:

- MPPC
- Scintillator
- MR compatible
- Structure



■ Absolute maximum ratings

Parameter	Condition	C13500-4075LC-12	C13500-3075LC-16	C13500-6075LC-16	Unit
Supply voltage		+24			V
Operating temperature	No condensation	+15 to +35			°C
Storage temperature	No condensation	0 to +50			°C

■ Specifications (Typ. Ta=25 °C, Vs=+24 V, unless otherwise noted)

Parameter	Condition	C13500-4075LC-12	C13500-3075LC-16	C13500-6075LC-16	Unit
Count rate		< 500 kcps	1 Mcps	< 250 kcps	-
CRT (FWHM)		< 280	< 280	< 400	ps
Power consumption		2.6	5.0	1.3	W
Power supply	Using C13502-02	+24			V

• Scintillator

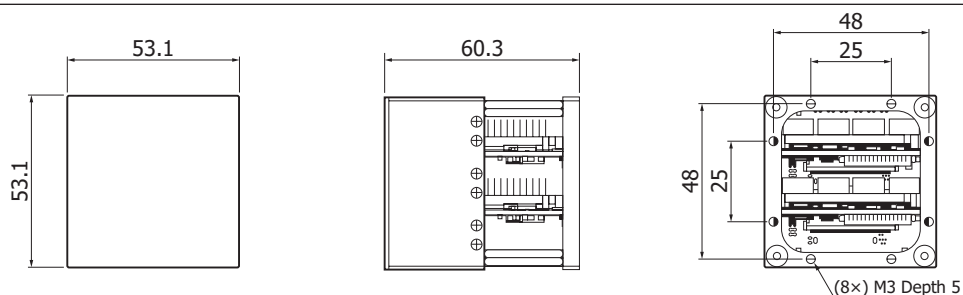
Parameter	C13500-4075LC-12	C13500-3075LC-16	C13500-6075LC-16	Unit
Material	LFS (Lutetium Fine Silicate)			-
Dimensions / ch	4.1 × 4.1 × 20	3.1 × 3.1 × 20	3.0 × 3.0 × 20	mm
Number of channels	144 (12 × 12)	256 (16 × 16)		ch
Element pitch	4.2	3.2	3.1	mm

• MPPC

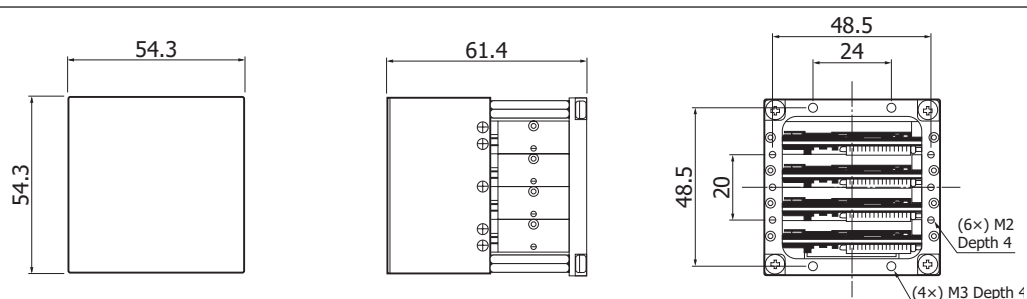
Parameter	C13500-4075LC-12	C13500-3075LC-16	C13500-6075LC-16	Unit
Type	TSV (Through Silicon Via)			-
Photosensitive area / ch	4 × 4	3 × 3	6 × 6	mm
Pixel pitch	75			μm
Number of channels	144 (12 × 12)	256 (16 × 16)	64 (8 × 8)	ch
Element pitch	4.2	3.2	6.2	mm

■ Dimensional outlines

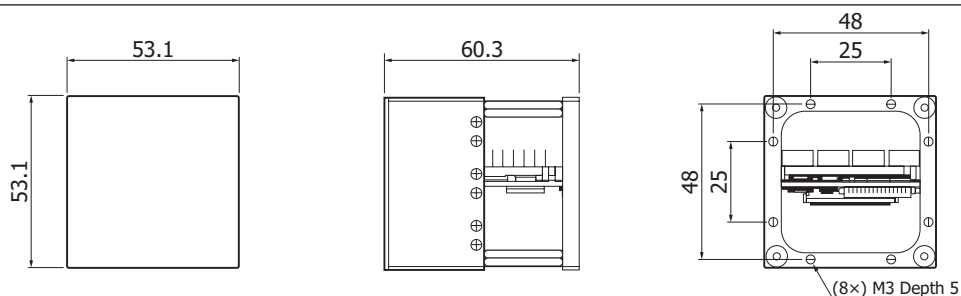
C13500-4075LC-12



C13500-3075LC-16



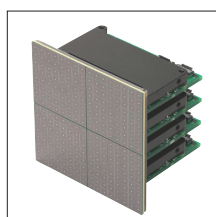
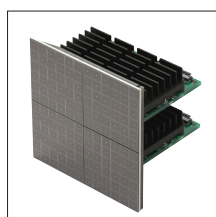
C13500-6075LC-16



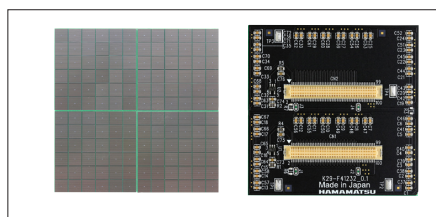
PET module without scintillator

MPPC + ASIC + Power

We can also provide only the MPPC array and ASIC board (without the scintillator). Contact us for details.



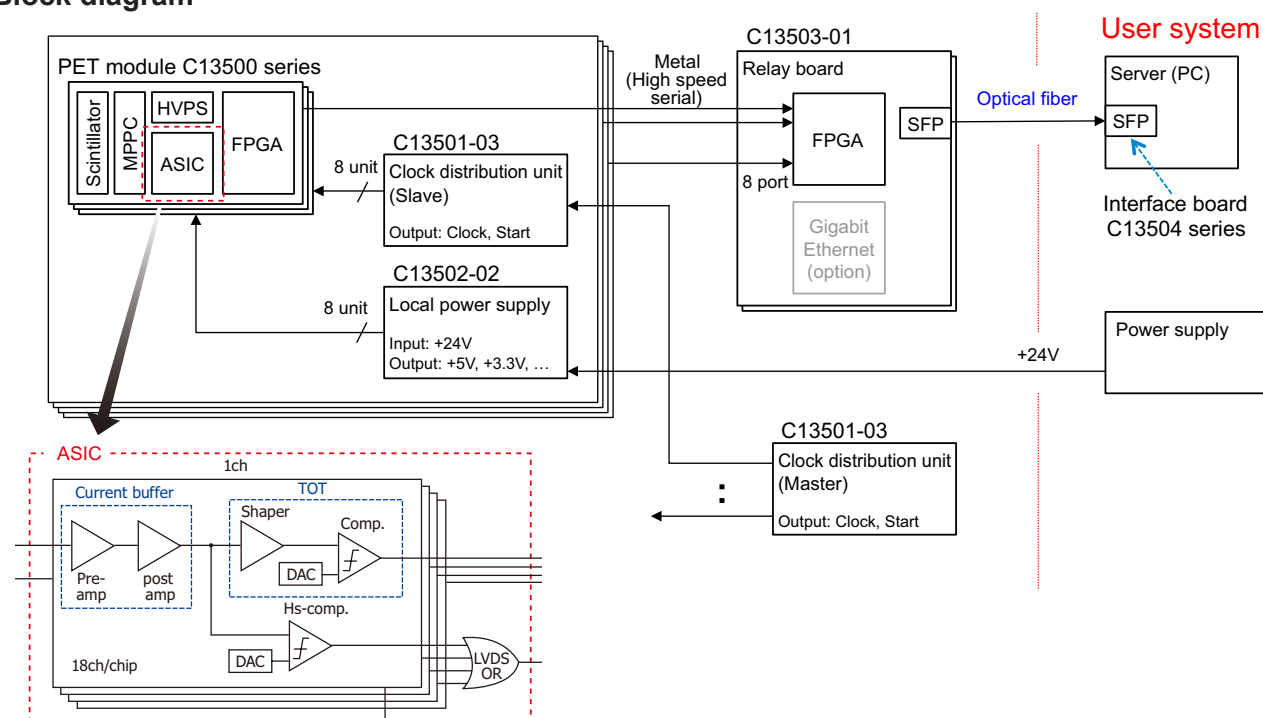
Without scintillator



MPPC array board

PERIPHERAL CIRCUIT

■ Block diagram



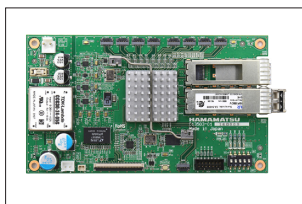
The C13501-03 provides sync signals that the PET module requires. It can distribute to sixteen signal processing units. It is also possible to distribute to up to 128 units by using several C13501-03s. The C13501-03 is designed on the assumption that it is connected to the PET module C13500 series.

- **Output signal: LVDS**
- **Distributes to 16 units**

This unit is able to provide a power supply that is required for the PET module. The C13502 can distribute power to eight PET modules. This unit is the ideal power source to operate the PET module C13500 series.

- The power supply is delivered to the PET module.
- Distributes to 16 signal processing units

Relay board C13503-01

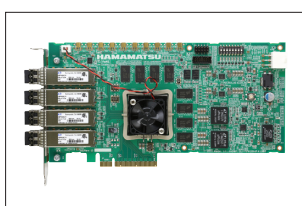


This C13503-01 gathers measurement data from PET module C13500 series and output data to PC via an optical fiber with high-speed data transfer.

Features

- High speed interface
 - 10 Gbps (SFP)
 - 3 Gbps (Metal)
- Connects to 8 PET modules as cascade line

Interface board C13504 series

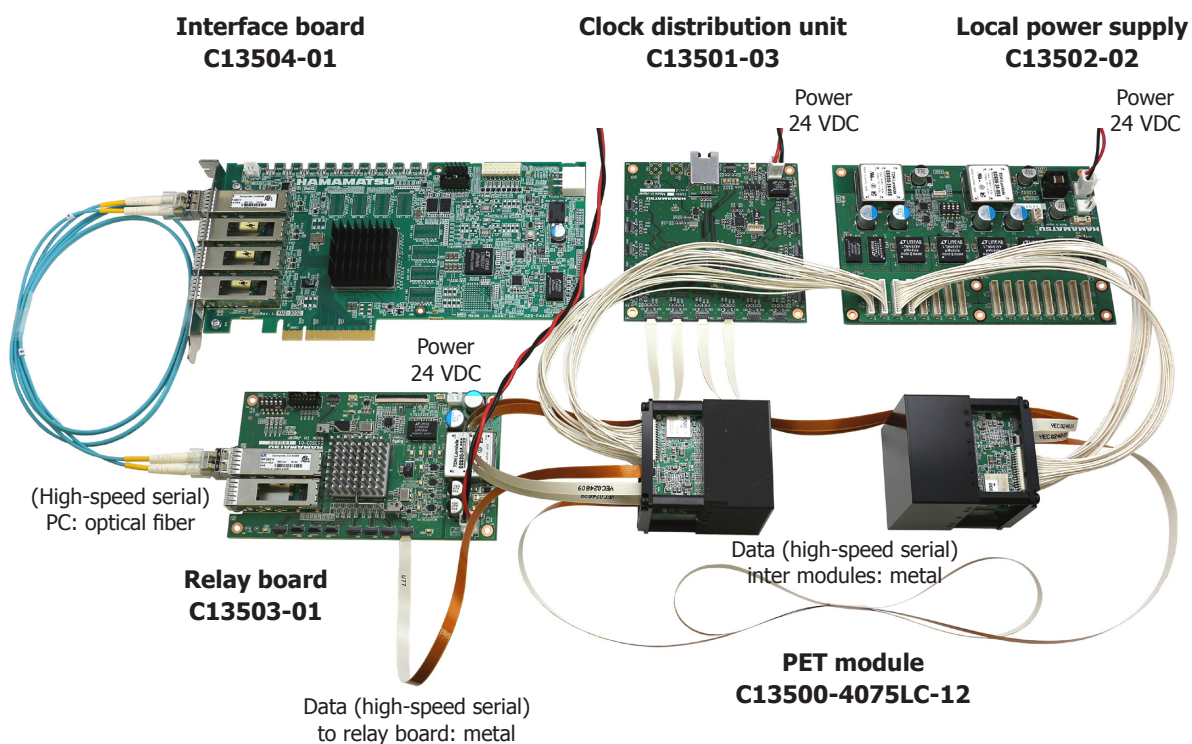


The C13504 series attach to the PCIe connector on a PC and easily collect measurement data in a PC with high-speed data transfer by connecting C13503-01.

Features

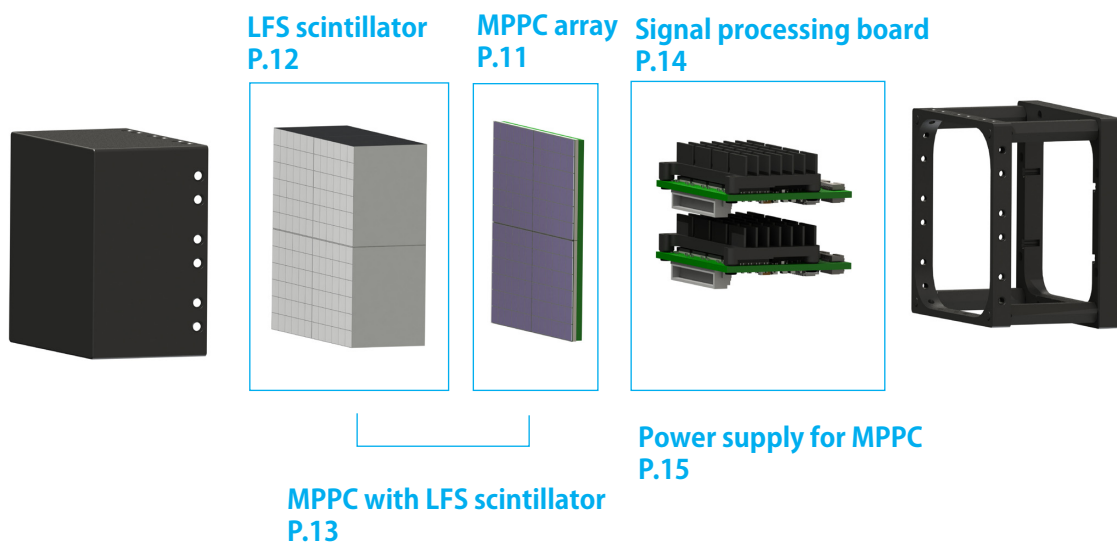
- High speed optical interface
 - C13504-01: 10 Gbps (SFP) cage × 2
 - C13504-02: 10 Gbps (SFP) cage × 4
- DDR4 memory 8 GB (C13504-02)
- Windows 7/10 (64-bit), CentOS 6.7 (64-bit)

■ Connection example



Component lineup



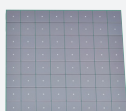
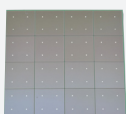
Hamamatsu Photonics not only sells modules but also components.



MPPC array

These are MPPC arrays for PET.

MPPC

Type no.		Effective photosensitive area (mm)	Number of channels	Pixel pitch (μm)	Number of pixels (per 1 channel)	Package	Fill factor (%)
	S13361-2050NE-04	2.0 × 2.0	16 (4 × 4)	50	1584	Surface mount type	74
	S13361-2050AE-04					Connector	
	S13361-3050NE-04	3.0 × 3.0	16 (4 × 4)		3584	Surface mount type	
	S13361-3050AE-04		Connector				
	S13361-3050NE-08		64 (8 × 8)			Surface mount type	
	S13361-3050AE-08		Connector				
	S13361-6050NE-04	6.0 × 6.0	16 (4 × 4)		14336	Surface mount type	
	S13361-6050AE-04		Connector				

■ Specifications (Ta=25 °C, Vover = 5 V)

Parameter		Value	Unit
Spectral response range		320 to 900	nm
Peak sensitivity wavelength		450	nm
Photon detection efficiency PDE*1 (λ=λp)		40	%
Dark count*2	Typ.	500	kcps
	Max.	1500	
Terminal capacitance		320	pF
Gain		1.7 × 10 ⁶	-
Breakdown voltage		53 ± 5	V
Recommended operating voltage		V _{BR} + 3	V
Temperature coefficient		54	mV/°C

*1: Photo detection efficiency does not include crosstalk or afterpulse.

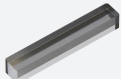

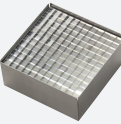
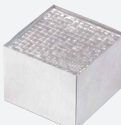
*2: Threshold = 0.5 p.e.

Note: The above characteristics were measured at the operating voltage that yields the listed gain.
(See the data attached to each product.)

LFS scintillator

LFS

We also accept orders for individual LFS scintillator arrays.

Type no.	Number of channels (ch)	Size/channel (mm)	Adhesive type
 J13059-3220LN	1 × 1	3.14 × 3.14 × 20	-
 J13059-3220LR-04	4 × 4	3.14 × 3.14 × 20	Reflective film
 J13059-3220LR-08	8 × 8	3.14 × 3.14 × 20	Reflective film
 J13427-1820LR-14	13 × 13 + 14 × 14	1.76 × 1.76 × 10 (2 layer)	Reflective film

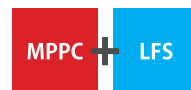
Scintillator specifications

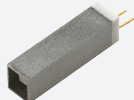

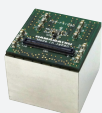
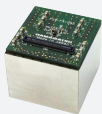
■ Specifications example (LFS scintillator)

Parameter	Value	Unit
Density	7.35	g/cm ³
Effective at. number	64	-
Attenuation length	1.15	cm
Decay constant	25 to 33	ns
Maximum emission	425	nm
Light yield (NaI:TI = 100 %)	80-85	-
Refractive index	1.81	-
Energy resolution ¹³⁷ Cs	8	%
Absorbed y-ray irradiation dose	10 ⁸	rad
Radiation hardness	7	%/cm
Hygroscopicity	No	-
Hardness, Moh	5.8	-
Cleavage	None	-

MPPC with LFS scintillator

These devices have LFS scintillator arrays coupled to MPPC arrays.



Type no.		Scintillator			Built-in MPPC array	
		Number of channels (ch)	Size/channel (mm)	Channel pitch (mm)	Number of channels (ch)	Pixel pitch (μm)
	S13900-3220LR	J13059-3220LN			+	S13360-3050CS
		1	3.14 × 3.14 × 20	-	1	50
	S13900-3220LR-04	J13059-3220LR-04			+	S13361-3050NE-04
		4 × 4	3.14 × 3.14 × 20	3.2	4 × 4	50
	S13900-3220LR-08	J13059-3220LR-08			+	S13361-3050NE-08
		8 × 8	3.14 × 3.14 × 20	3.2	8 × 8	50
	S13901-1820LR-14	J13427-1820LR-14			+	S13361-3050NE-08
		13 × 13 14 × 14	1.76 × 1.76 × 10	1.8	8 × 8	50


■ Comparison chart

Material	Density (g/cm ³)	Light yield (NaI=100 %)	Decay (ns)	Application
LFS	7.35	85	33	PET, HEP
LYSO	7.25	80	41	PET, HEP
NaI:Tl	3.67	100	230	γ-ray, X-ray
CsI	4.53	120	1050	X-ray CT
CWO (CdWO ₄)	7.68	40	5000	X-ray CT
BGO (Bi ₄ Ge ₃ O ₁₂)	7.13	12	300	PET, HEP
PWO (PbWO ₄)	8.20	1.3	10	HEP
GAGG	6.63	140	88	HEP

Signal processing board

ASIC

This is a signal processing circuit designed specifically for Hamamatsu MPPC arrays for PET.

Type no.		C14139-01
		
Front-end ASIC	Type	18 ch Low power FE ASIC
	Number of ASIC	4
	Number of input node	72 (18 × 4) ch
MPPC power supply	Type No.	C11204-02
	Number of modules	1
Power consumption		1.3 W

■ Specifications

• Absolute maximum ratings

Parameter	Condition	Value	Unit
Operating temperature	No condensation	+15 to +35	°C
Storage temperature	No condensation	0 to +50	°C

• Signal processing board (Typ. Ta=25 ° C, unless otherwise noted)

Parameter	Condition	Value	Unit
Maximum count rate		500	kcps
Power supply		+5V, +2.5V, +1.9V, +1.8V, +1.5V, +1.1V	V
Ref. clock frequency		50	MHz





• MPPC power supply (Typ. Ta=25 ° C, Vs=+5V, unless otherwise noted)

Parameter	Condition	Value	Unit
Stability		±10	ppm/°C
Output voltage	No load	40 to 90	V
Maximum output current		2	mA
Ripple noise	Vout=72V, no load	0.1	mVp-p

Power supply for MPPC

Power

Bias power supply with built-in high precision temperature compensation for MPPCs.

Type no.		Mount	Stability (ppm/°C)	Temperature sensor	Voltage boost (MR compatibility)
	C11204-01	Pin	±10	Analog	Inductor (No)
	C11204-02	Surface	±10	Analog	Inductor (No)
	C11204-03	Pin	±30	Analog	External (Yes)
	C11204-04	Surface	±30	Digital	External (Yes)

■ Electrical characteristics (C11204-02, typ. Ta=25 °C, Vs=+5 V, unless otherwise noted)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	Vs		4.75	5	5.25	V
Current consumption	Icc	Vo=72 V, no load	-	20	-	mA
Output voltage	Vo	No load	-	40 to 90	-	V
Output current	Io		0	-	2	mA
Ripple noise ^{*1}	Vn	Vo=72 V, no load	-	0.1	0.2	mVp-p
Setting precision	-	Vo=72 V, no load	-	±10	-	mV
Setting resolution	-		-	1.8	-	mV
Temperature stability	-	25 ± 10 °C Vo=72 V, no load	-	±10	-	ppm/°C
Interface	-		Serial communication (UART)			-

*1: Using the recommended circuit.

HAMAMATSU

www.hamamatsu.com

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France: Hamamatsu Photonics France S.A.R.L.: 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10

United Kingdom: Hamamatsu Photonics UK Limited: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, UK, Telephone: (44)1707-294888, Fax: (44)1707-325777

North Europe: Hamamatsu Photonics Norden AB: Torshamnsgatan 35 16440 Kisra, Sweden, Telephone: (46)8-509-031-00, Fax: (46)8-509-031-01

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